THE DESIGN OF AN EFFICIENT AND RELIABLE STREAMLINE METHOD FOR COMPOSITIONAL RESERVOIR SIMULATION

M. Gerritsen[a], K. Jessen[a], F.M. Orr Jr.[a] and B. Mallison[a]

[a]Department of Petroleum Engineering
Stanford University
Stanford, CA 94305-2220
margot.gerritsen@stanford.edu

The fundamental objective in our research group is to understand the physical mechanisms that control displacement performance in gas injection processes and use that understanding to develop efficient and accurate computational tools for prediction of project performance at field scale. In this paper, we will present our research work on the design of efficient streamline methods compositional reservoir simulations.

Previous research on the interplay of viscous fingering, gravity segregation and permeability heterogeneity indicates that in many reservoir settings, the flow is dominated by the heterogeneity of the reservoir rocks. Thus any simulation tool that we use for field-scale predictions must be able to handle high resolution representations of the heterogeneous permeability field if it is to represent the flow realistically. In addition, gas injection processes are fundamentally compositional. It is the interaction of phase behavior and flow that controls local displacement efficiency in high pressure gas drives. Compositional simulation is appropriate for such flow systems. Unfortunately, conventional compositional finite difference simulators are too computationally intense for high resolution 3D computations to be practical, and computations with coarser grids are generally badly affected by numerical dispersion.

We are developing the streamline compositional simulation approach for gas injection processes. Streamline methods decompose the problem into a 3D pressure solve used to determine the streamlines and a set of 1D computations along those streamlines that represent the physics and chemistry of the displacement. The streamline methods are fast if the flow is dominated by heterogeneity as the positions of the streamlines change slowly in time allowing for larger time steps relative to the FD approach. In addition, streamline methods are natural candidates for parallel computations and adaptive mesh refinement on the pressure grid as well as the streamline grid.

Along the streamlines we move the components using analytical solutions for multicomponent displacements whenever possible. The analytical solutions were recently derived in our group for 2-phase flow and constant initial conditions [1]. The combination of streamlines and analytical solutions is competitive with conventional finite difference compositional simulations and can be obtained with orders of magnitude less computation time [2]. When analytical solutions are insufficiently accurate, we use high order upwind finite difference methods to move the compositions [3]. We are currently investigating high order streamline tracing and streamline mapping algorithms to increase accuracy, and are implementing adaptive mesh refinement techniques to further improve efficiency.

References

[1] K. Jessen, Y. Wang, P. Ermakov, J. Zhu and F. M. Orr Jr., “Fast, Approximate Solutions for 1D Multicomponent Gas Injection Problems”, *SPE 56608/SPE74700*, December 2001.
[2] C.J. Seto, K. Jessen and F.M. Orr Jr., “Compositional Streamline Simulation of Field Scale Condensate Vaporization by Gas Injection”, *SPE 79690, SPE Reservoir Simulation Symposium*, Houston, TX, February 3-5, 2003.
[3] B. Mallison, M. Gerritsen, K. Jessen, F.M. Orr Jr., “High Order Upwind Schemes for Two-Phase, Multicomponent Flow”, *SPE 79691, SPE Reservoir Simulation Symposium*, Houston, TX, February 3-5, 2003.